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SURFACE CATCHES OF MARINE DIATOMS
AND DINOFLAGELLATES MADE BY
U.S.S. "PIONEER" IN ALASKAN
WATERS IN 1923

BY
WINFRED EMORY ALLEN

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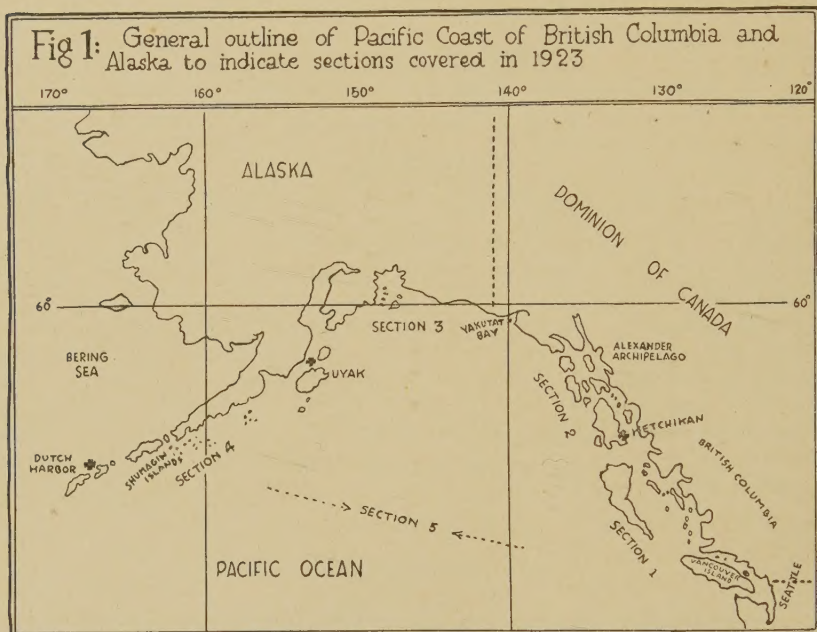
LOCATION

This is the last of three reports which cover the results of study of surface collections of microplankton taken in coastal waters of the Northeast Pacific Ocean by the U. S. Coast and Geodetic Survey steamer *Pioneer* in 1923 (Allen, 1923, 1924). The Alaskan series was begun at Seattle on April 21, 1923. Catches were made at two-hour intervals while in transit, until they were suspended for the summer, at Unimak Island, on June 30. With catches at hourly intervals, the series was resumed in October on the run across the high seas, outside of the Gulf of Alaska, to Seattle, at the close of the season of Alaskan operations by the U. S. Coast and Geodetic Survey.

METHODS

In all cases, five gallons of water were dipped from the surface while the boat was at ordinary running speed, and this water was filtered through a small, conical net of silk bolting cloth (No. 25) according to the standard method of the Scripps Institution. Formaldehyde was the only preservative used, because this has been found to be the best preservative of such material for purposes of statistical study.

The total number of catches taken north of Seattle was two hundred and eighty-four, one hundred and sixty-nine of which were taken on the homeward run in October. Probably the distances between points of collecting were usually about twenty-four miles in the two-hour intervals and twelve miles in the one-hour intervals.



ROUTE

For convenience of discussion, the route covered in obtaining this series (which included forty-three degrees of longitude and twelve degrees of latitude) has been divided, with only partial success, into five sections based on geographic characters. The sections (fig. 1) are:

1. Seattle to Ketchikan, through the straits east of Vancouver Island, Princess Royal Island, Banks Island, and others of like situation.
2. Ketchikan to Yakutat Bay through Clarence, Sumner, Chatham, and Icy Straits and the Gulf of Alaska.
3. Yakutat Bay to Uyak through the Gulf of Alaska, Prince William Sound, the Gulf of Alaska again, and Kupreanoff Strait.
4. The Aleutian Island section, from Uyak to Dutch Harbor, running off-shore from the Alaska Peninsula and then through Unimak Pass, and returning to Unimak Island over the same course.
5. Unimak Island to Seattle by direct route across the north Pacific Ocean toward Vancouver Island, and then off-shore to the Strait of Juan de Fuca and Puget Sound.

GENERAL DISCUSSION

In the first four sections, at least a few diatoms were recorded for every catch, and in the series across the high seas there were only five catches for which no diatoms were recorded. In the first section, represented by twenty-eight catches, nine exceeded 100,000 diatom cells to the liter; in the twenty-seven catches of the second section, seventeen catches exceeded 100,000; in the twenty-seven catches of the third section, fourteen; in the thirty-three catches of the fourth section, thirteen; and in the one hundred and sixty-nine catches of the fifth section, one catch exceeded 100,000 diatom cells to the liter. Seventy-six species, representing thirty-seven genera, were recorded for the series as a whole, taken in a little over 4,000 miles of cruising.

DINOFLAGELLATES

In no section did the dinoflagellates reach the number of 3,000 cells to the liter, and in most cases they were fewer than 1,000 cells to the liter. There were also some catches in all sections for which no dinoflagellates were recorded. There were at least thirty-one species, representing ten genera in the series as a whole. On account of their small numbers they will receive no further attention in this report.

TABLE 1
NUMBER OF GENERA, SPECIES, TOTAL NUMBER OF CATCHES, AND NUMBER OF
CATCHES EXCEEDING 100,000 CELLS FOR EACH SECTION

	Genera	Species	Catches	Catches over 100,000 cells
Section 1.....	17	33	28	9
Section 2.....	21	43	27	17
Section 3.....	15	42	27	13
Section 4.....	17	44	33	13
Section 5.....	28	57	169	1

DIATOMS

Thirty-three species of diatoms (table 1) representing seventeen genera, were listed in the section between Seattle and Ketchikan. None of these were taken in very large numbers until the northern portion of the Strait of Georgia was reached, where there was a large catch (408,792 cells to the liter) consisting mainly of *Chaetoceras debile* Cl. and *Thalassiosira nordenskioldii* Cl. No other catches

of exceptional size were obtained until the region just north of the north end of Vancouver Island was reached. There, two succeeding catches (259,225 and 3,228,661 cells to the liter) were obtained in which *Chaetoceras debile* Cl. was far the most prominent species, although *Skeletonema costatum* (Grev.) was conspicuous, and *Thalassiosira nordenskioldii* Cl. moderately so. Two fairly large catches, consisting mainly of three species of *Thalassiosira*, were taken in the southern portion of the relatively narrow channel on the eastern side of Princess Royal Island, but the following catch was relatively light (44,505 cells). Two heavy catches followed, consisting mainly of *Chaetoceras debile* Cl. from the north end of Princess Royal Island and the east side of the south end of Pitt Island. Succeeding catches (in the region near the mouth of the Skeena River) were very light until a fairly large catch was made about ten miles southeast of Duke Island. It was followed by a heavy catch (1,584,128 cells) about the same distance northward from Duke Island. *Skeletonema costatum* (Grev.) was the most prominent and *Thalassiosira nordenskioldii* Cl. conspicuous.

Forty-three species, representing twenty-one genera (table 1) were listed in the section between Ketchikan and Yakutat Bay. About half of the twenty-seven catches were greater than 300,000 diatom cells to the liter. Three moderately large catches (consisting mostly of a small *Chaetoceras*) in Clarence Strait were followed by a very light catch (16,282 cells) in Sumner Strait. Four large catches in the southern half of Chatham Strait were followed by two very light catches and then two very heavy catches (3,868,883 and 6,761,847 cells to the liter, the latter the largest number yet recorded in some thousands of catches examined at the Scripps Institution). The small *Chaetoceras* species retained the leading place in numbers in these catches. Through Icy Strait to Cape Spencer the three catches were all relatively light. Near and to seaward of Cape Spencer two catches consisting mainly of *Chaetoceras debile* Cl. were very heavy (3,855,271 and 2,656,306 cells to the liter). Two very light catches were then taken before the next very heavy catch (mainly *Chaetoceras debile* Cl. and *C. scolopendra* Cl.) off Lituya Bay. This was followed by a catch of moderate size off Cape Fairweather, succeeded by two catches (3,923,754 and 4,545,216 cells to the liter), larger than any except the one taken in Chatham Strait. *Chaetoceras debile* Cl. was most prominent, with *C. scolopendra* Cl. and some other small forms of the genus present in notable numbers. The next two catches, off-shore from Yakutat Bay, were very light.

Forty-two species (table 1) representing fifteen genera, were noted in the section between Yakutat Bay and Uyak. Of the twenty-seven

catches, fourteen yielded more than 200,000 cells to the liter. In all of these *Chaetoceras debile* Cl. was distinctly the most abundant species, although some kinds of *Thalassiosira* were conspicuous in most of them. Four of the largest catches were obtained off-shore from Icy Bay and Bering Glacier, two others near Cape St. Elias, and seven in Prince William Sound or coastwise to a point south of Resurrection Bay. Catches from the vicinity of Nuka Bay to Marmot Bay, at the north end of Kodiak Island, were very small, four containing only about 1,000 diatom cells to the liter. Catches in Kupreanoff Strait and the waters just west of the north end of Kodiak Island were larger, but still very small as compared with those taken earlier, to the eastward and northward.

Forty-four species (table 1), representing seventeen genera, were found in the Aleutian Islands section. Only thirteen of the thirty-three catches were greater than 100,000 diatom cells to the liter. None of the fourteen catches obtained off-shore from the Alaskan Peninsula, between Uyak and the west side of the Shumagin Islands, approached 100,000 cells to the liter. Near the Shumagin Islands and between them and Unimak Island, five of the catches were larger than 100,000 cells. These consisted mainly of *Chaetoceras debile* Cl. with *C. scolopendra* Cl. and other small forms of the genus next in number. *Thalassiosira nordenskioldii* Cl. was also prominent. On May 19 catches were discontinued for some weeks at Unimak Island. They were begun again on June 28, on a round trip to Dutch Harbor which showed interesting differences between some catches made while westbound and those made over the same route when eastbound, less than two days later. While westbound on June 28 the five catches to southward from Unimak Island were very light, none reaching 100,000 cells to the liter. Of the three obtained south of that island on the return trip two were in excess of 200,000. A catch taken north of Akun Island while west-bound yielded over 600,000 cells to the liter, but the catch taken while east-bound thirty hours later near the same place was only about half as large. The four catches taken between Akun Island and Unalaska Bay were all greater than 100,000 cells. *Chaetoceras debile* Cl. was most prominent in nearly all the larger of these catches, although *C. scolopendra* Cl. and other small forms were numerous. In the last two catches south of Unimak Island *Leptocylindrus danicus* Cl. came into prominence.

In October fifty-seven species (table 1), representing twenty-eight genera, were obtained in the fifth section (mostly oceanic), between Unimak Island and Seattle. Only eight out of the one hundred and sixty-nine catches yielded more than 20,000 diatom cells to the liter. These were all in the region off the west coast of Vancouver Island,

or in the Strait of Juan de Fuca. The largest (428,847 cells) was in the Strait. *Chaetoceras sociale* Laud. contributed the largest numbers of cells, but *C. debile* Cl., *Skeletonema costatum* (Grev.), and *Eucampia zoodiacus* Ehr. were also prominent. No other catches reached the number of 5,000 diatom cells to the liter except eight in the region of the Shumagin Island (largest yielding 19,086 cells) and one in mid-ocean (5,015 cells) in Lat. 53° 34' N, Long. 144° 54' W. In these catches *Leptocylindrus danicus* Cl. and the genus *Coscinodiscus* were most prominent.

In the series as a whole, eight species of diatoms, representing four genera, were in striking prominence in one or more localities. These were *Chaetoceras compressum* Cl., *C. debile* Cl., *C. scolopendra* Cl., *C. sociale* Laud., *Leptocylindrus danicus* Cl., *Skeletonema costatum* (Grev.), *Thalassiosira decipiens* (Grun.), and *Thal. nordenskioldii* Cl. Several other forms appeared in some catches in rather large numbers, but they do not demand particular notice in this brief general survey of the Alaskan field.

Chaetoceras debile Cl. (more or less constantly including *C. curvisetum* Cl.) was the numerically leading species at more stations than was any other. Among the larger catches, the lead was taken by *Skeletonema costatum* (Grev.) once, just north of Duke Island, by small, unidentified species of *Chaetoceras* in Chatham Strait, and by *C. sociale* Laud. in the Strait of Juan de Fuca (in October). *Leptocylindrus danicus* Cl. was the leading species in the relatively large (locally), but actually small, catches (less than 20,000 cells to the liter) near the Shumagin Islands in October. *Thalassiosira nordenskioldii* Cl. and *Thal. decipiens* (Grun.) were noticeably abundant in many catches, but the numbers in the large catches were almost always less than those of one or more species of *Chaetoceras*. A similar statement may be made concerning the total numbers representing these two genera. In the matter of volume, however, it is possible that the latter statement might be reversed. Certainly, most cells of *Thalassiosira* were larger than those of the various species of *Chaetoceras*. The colonies of *Thalassiosira* were very conspicuous, and this particular series of catches gives the impression that the genus is normally much more prominent in Alaskan waters than it is off the California coast. It is rarely very noticeable in catches from the San Diego region.

The prominence of the genus *Thalassiosira* appears to be the main characteristic of the Alaskan series which can be said to be distinctive as compared with series of catches in southern California waters. On the other hand, the prominence of the genus *Chaetoceras* is in remarkable agreement with the southern region, and in some cases it is so

great that nothing but the label serves to show its northern origin. But, it is also noteworthy that some catches of *Chaetoceras* were distinctive by reason of the presence of resting spores. These were fairly numerous in some of the Alaskan material, but they are rare in the San Diego territory, at least in surface catches.

RELATION TO LATITUDE

To a marked degree, this series supports the oft-repeated generalization that plankton production is heavy in high latitudes. Not only were some catches heavier than any previously examined at the Scripps Institution, but, in proportion to the total number of collections, there were much larger numbers of very heavy catches. On the other hand, many of the heavy catches were closely followed by others which were astonishingly light. Such extreme differences indicate sharp localization of influences which can scarcely be dependent upon mere latitude. Furthermore, the production of plankton is no more exuberant than the vernal production of life on land in similar latitudes, and it is surely possible that the total production, for the year, may be less than that in lower latitudes, in the sea as well as on the land. It may really be true that high latitudes are most highly productive of plankton, but it is surely more obviously true that we know too little about maxima and minima of production, annual and seasonal ranges of production, and geographic range and localization of production, to make valid comparisons of productive values of different latitudes, as such.

RELATION TO TOPOGRAPHY

All the large catches in this Alaskan series were taken fairly close (within thirty miles), or very close, to land, in regions of heavy precipitation and, consequently, heavy drainage. No analysis of the conditions of production can be adequate unless it includes careful consideration, both qualitative and quantitative, of the influence of such drainage. But, in fact, the information essential for adequate analysis, either of plankton distribution in the region, or of drainage (or other) influences upon this distribution, is not available, and detailed discussion is not now warranted.

Although this series indicates that the narrow straits and channels of the Alexander Archipelago are more highly productive than more open waters, it does not warrant a positive statement to that effect, primarily because of differences in times and seasons in taking the

different parts of the series. For example, we may suspect that Section V was not highly productive at any time, but no one actually knows the character of its surface production in April and May of 1923, not to mention the possible differences at subsurface levels. So far as we have tangible evidence, the production in the Alexander Archipelago may have been mainly confined to the surface level, while that in the open sea may have been largely confined to the thirty-meter (or some other) level. Because of overcrowding, it is difficult for one to imagine that subsurface catches could have been much heavier than those surface catches which yielded millions of cells to the liter, but we do know from other series that subsurface catches may reach millions to the liter where surface catches are relatively light.

RANGE OF TEMPERATURE

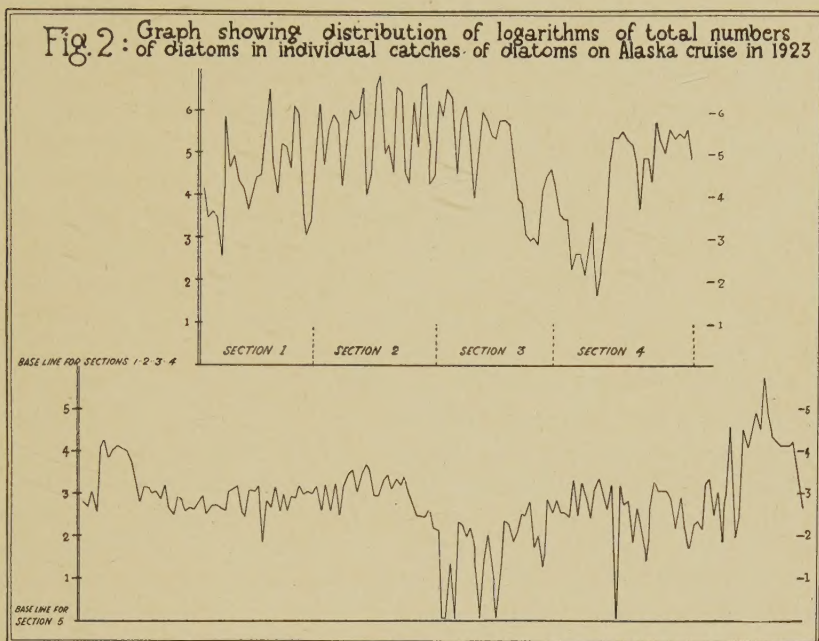
The only hydrographic information available is that concerning surface temperatures at points of collecting. The following table gives the main bearing of this information upon the problem of relationship between diatom production and temperature of the surrounding water. In this summary there are three prominent points.

TABLE 2
TEMPERATURES WITH SELECTED CATCHES

	Temperatures (F) in ten largest catches			Temperatures (F) in ten smallest catches		
	Highest	Lowest	Average	Highest	Lowest	Average
Section 1.....	49.0°	45.5°	47.3°	54.0°	46.0°	48.0°
Section 2.....	46.5	43.5	44.7	48.5	41.0	44.6
Section 3.....	46.5	42.5	44.8	44.5	41.0	42.2
Section 4.....	45.5	39.4	42.2	41.0	39.7	40.0
Section 5.....	54.5	47.5	51.0	53.5	52.0	52.7

First, it is evident that the range of temperature among the ten most productive catches is not significantly different from the range among the ten least productive catches in each section. Second, it is shown that fairly heavy production (in this case over 350,000 diatom cells to the liter) may occur in a rather low temperature (39.4° F.). Third, it is apparent that no certain degree of temperature can be designated as most favorable, nor any other as least favorable, to production.

Fig. 2: Graph showing distribution of logarithms of total numbers of diatoms in individual catches of diatoms on Alaska cruise in 1923



SUMMARY

1. Certain localities were surpassingly productive of diatoms at the time of collecting in this series (fig. 2).

2. Other localities (some near to, but most of them remote from, the heavily productive) were very lightly productive at the time of collecting.

3. Most of the species of diatoms caught were the same as those commonly found in the California region.

4. The genus *Thalassiosira* was much more prominent in most sections of the series than it has been found to be in collections south of San Francisco.

5. Dinoflagellates were poorly represented throughout this series.

6. Catches near land were heavier than those remote from land (fig. 2). The average yield of the 115 catches of the first four sections (near land) was 559,401 cells to the liter, while the average yield of the 169 catches of the fifth section was only 6,110.

7. The influence of temperature on surface production is not such as to be recognized in this series.

8. The largest catches were not in the highest latitudes.

9. Distribution of the whole group of diatoms is not uniform, or regular, in this series (fig. 2). The distribution of species of diatoms is even less regular.

10. Leadership in diatom production seems to be confined to a few highly adaptable species.

11. Such organizations as the U. S. Coast and Geodetic Survey can do highly valuable field work in certain lines of biological oceanography without disturbing their special program of operations.

12. With these Alaskan collections the Scripps Institution has completed a series of observations on surface distribution of diatoms which has reached an extent of over 7,000 miles along the eastern shores of the Pacific Ocean, from Callao, Peru, to Dutch Harbor, Aleutian Islands. These observations, though discontinuous in much of the territory covered, have shown that in part, at least, of this territory there may be distinct differences in degree of productivity in particular localities in succeeding years. In addition, there is evidence that neighboring localities, having apparently similar conditions, may yield very different numbers and kinds of diatoms and dinoflagellates. Finally, along all of these coasts, there is a remarkable similarity of species found, although there is an apparent tendency for some species or genera to be limited to certain regions, or to be poorly represented in certain regions.

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